Dr. Wichuda Kowtanapanich

Faculty of Civil Engineering, Mahasarakam University

Black Spot Identification

Methods in Thailand

Abstract

This article presents an overview of Black Spot Identification in Thailand. The paper, firstly, describes traffic accident problems as well as the proposed countermeasures in the country. The black spot improvement programs especially the current practiced and researches to identify black spot locations are highlighted. Both conventional method and public participation method to identify the black spot locations are discussed. Lastly, available technologies to facilitate the identification processes are also mentioned in this article.

Key words : Traffic Accident, Black Spot Identification, GIS

1. Introduction

Of all the systems with which people have to deal everyday, road traffic systems are the most complex and the most dangerous (1). Globally, as projected by the WHO that road traffic disability-adjusted life years (DALYs) loss will move from being the ninth leading cause of DALYs in 1999 to the third leading cause by year 2020 as shown in Table 1 (2).

In Thailand, the Thais are killed on the roads with an average of around 12,000 persons per year or about 2 persons per hour (3). In other words, every day, approximately 50 Thai people who leave homes to work, school, shop, temple/church/mosque, social gathering never return homes because of road accidents. Road accidents have not caused only lives and disability to the Thai citizens but also substantial damages to the country's economy (3). It was estimated that the economic losses due to road accidents in Thailand are over 100,000 million Baht per year, which means over 12 million Baht per hour or about 3.4% of the country GNP (3).

To alleviate road safety problems in Thailand, Tanaboriboon (4) proposed the safety countermeasures matrix, followed Dr. Haddon's (5) framework, presented as shown in Table 2. It can be seen from the table that the proposed countermeasures involving all components of accident (road user, vehicles, road and environment) in the three-related phases of time (pre-crash, during crash, and post-crash). Countermeasures are composed of enforcement, education and campaign and engineering and emergency medical service approaches in dealing with the three contributing components of accidents: road users, vehicles, and road and environment.

As it is not possible to elaborate on all these measures in this article, only engineering measure focusing on black spot improvement program is highlighted in the following sections.

Table 1 Disease Burden (DALYs lost) for 10 Leading Causes

1998 **Disease or Injury**	**2020** **Disease or Injury**
1. Lower respiratory infections	1. Ischaemic heart disease
2. HIV/AIDS	2. Unipolar major depression
3. Perinatal conditions	***3. Road traffic injuries***
4. Diarrhoeal diseases	4. Cerebrovascular disease
5. Unipolar major depression	5. Chronic obstructive pulmonary disease
6. Ischaemic heart disease	6. Lower respiratory infections
7. Cerebrovascular disease	7. Tuberculosis
8. Malaria	8. War
9. Road traffic injuries	9. Diarrhoeal diseases
10. Chronic obstructive pulmonary disease	10. HIV/AIDS

Table 2 Proposed Road Safety Countermeasures for Thailand (Safety Planning Countermeasures Matrix)

	Road Users	Vehicles	Road & Environment
Pre-Crash	***Enforcement & Education & Campaign*** • Over Speeding • Alcohol/Drugs use • Physical Impairment • Young Drivers • Driver License	***Vehicle Inspecting Program*** • Breaking System, Lighting, Tire • Inspecting Agency ***Vehicle Standards and Modifications*** • Public buses • Trucks ***Vehicle Visibility*** • Reflective material • Daytime running Headlights	***Road Engineering Program*** • Road Safety Audits • Black Spots Treatment • Traffic Management System (Ex. traffic calming) • Traffic Control Devices • Motorcycle lanes • Zero pothole • Accident Database System ***Community Based Approach*** • Public Participation • Bottom Up Approach
Crash	***Compliance of Safety Devices*** • Use of Restraints (Helmet, Seat belt) • Child Restraints (Proper child seat)	***Vehicle and Occupants Safety Features*** • Restraint System • Interior (Airbags) • Exterior (Crash Protection) ***Crash Compatibility*** • Under run bars (Truck) • Bull Bar (Pick up truck)	***Roadside Hazard Treatment*** • Forgiving Road Furniture • Collapsible Facilities • Crash Barrier • Crash Cushion
Post-Crash	***Skill of Paramedics*** • First Aid, Initial proper medical treatment • Rescue Skills • ERP (Emergency Response Plan)	***Ease of Evacuation*** • Vehicle related eg. door opening, fuel leakage • Rescue Tools	***Trauma Management*** • Rescue work • Accessibility of rescue team • EMS • Rehabilitation Program

2. What is Black Spot?

Black spot is a term used to refer to a section of road that is regarded as a high-risk location for car crashes (6). Black spot programs are designed to reduce the crash risk in these areas by improving the physical conditions or management (e.g., building roundabouts, improving lighting).

To improve the physical conditions of the roadway, the accident mitigation process was divided into several steps. Identification of locations for safety improvement is the starting point of all the processes. The process is sometimes known as "Black spot identification or hazardous location identification". Recently, the term "identification of sites with promise" has also been used (7). However, the most widely used technique to determine whether a site has a safety problem is based on the road accident history and this is known as determination of "black spot location". Also, the whole accident mitigation process is often referred to as black spots improvement program.

In Thailand, a black spots definition is given by the SweRoad of Sweden in 1999 when the Ministry of Transport and Communications commissioned the SweRoad of Sweden together with local consultants to carry out a comprehensive road safety project in Thailand (8). Among various proposed strategies, black spot improvement program is also presented. The study team defined a black spot as a location where many accidents have occurred and/or the risk of being involved in an accident is high, and the risk of being injured in an accident is high. A black spot may be an intersection, or a section of road, or any other location that fulfils the definition.

3. Identification Methods

To make the road safer, it is important to identify the right site for safety improvement, if not, resources can be wasted on sites that are incorrectly identified as potentially unsafe but sites that are truly unsafe can go untreated and remain unsafe. Therefore, black spot identification is an essential step for black spot improvement program.

The technique to determine a black spot location varies from place to place. Methodologies vary from the simple flag sites that have high-accident records to the more complicated ones of which the expected number of accidents is estimated and potential for safety improvements is determined. The following subsections discuss the method to identify black spot including the method used in Thailand as well as a statistical approach used in this manner.

3.1 Number of accidents method

This method uses the number of accidents at a location to identify its safety performance. Locations with more than a predetermined number of accidents are classified as high-accident locations.

3.2 Accident density method

The accident density is calculated from the number of accidents per unit length for a section of highway. Sections with more than a predetermined number of accidents are classified as high accident locations.

3.3 Accident rate method

This method uses accident numbers divided by vehicle exposure to provide rates such as accidents per million entering vehicles per spot location and accidents per million vehicle-miles for sections of highways. Locations with higher than a predetermined rate are classified as high-accident locations.

3.4 Severity index method

The concept of this method is that the number of fatal and/or injury accidents at a location or section of highway are given a greater weight than property-damage-only accidents.

Cautions should be exercised to select the proper weights when using this method. The weights should ideally be based on

socio-economic values. In reviewing the literature, several weights values were proposed for Thailand.

In 1986, JICA estimated the monetary values as follows: Fatality: 0.9 Million Baht, Injury: 0.09 Million Baht, Property Damage Only (PDO): 0.02 Million Baht. These values, however, were estimated from the benefits of persons who were saved from traffic accident through the implementation of the traffic safety plan. Hence, the weights for Fatality: Injury: Property Damage only estimated by Kao (9) were 45 EPDO: 4.5 EPDO: 1 EPDO, respectively.

In 1998 Panwai (10) estimated these weights based on economic losses of the accident victim. The findings (Fatality: Injury: Property Damage only) were 13 EPDO: 2 EPDO: 1 EPDO, respectively.

In 2004 Luathep(11) determined the monetary value of road accidents in Khon Kaen Municipality and revealed that in terms of accident cost, cost ratio for Fatal, Injury, and Property Damage Only (PDO) accidents are 3,538,130 Baht, 245,795 Baht, and 28,379 Baht, respectively. Therefore, the weights for Fatal, Injury and PDO accident are then 125:9:1 (12).

3.5 Quality control method

The logic of this method is that a location is considered to be a black spot if its safety parameter shows higher values than the critical value. They assured control of the quality of the analysis by applying a statistical test. This is based on the assumption that occurrences of traffic accident follow the Poisson distribution (variance = mean). Several parameters can be used such as accident rate, accident frequency, and accident severity.

For example, when using accident rate as a parameter, the locations with an Accident Rate that is greater or significantly greater than the average Accident Rate for the similar region are pointed out. In other word, the locations with accident rate greater than the critical rate are classified as a black spot location. The critical rate (R_c) with 95 percent confidence is shown in Equation 1 (13).

$$R_c = R_a + 1.645\sqrt{\frac{R_a}{m}} - \frac{0.5}{m} \qquad (1)$$

Where R_a = Average accident rate for category of highway being studied, m = Vehicle exposure at location.

3.6 Combined method

SweRoad (8) employed the three parameters including accident rate, accident frequency and accident severity to identify black spot locations in two provincial in Thailand. In this method, location will be identified as black spot even if only one safety parameter is greater than its own critical value. The three safety parameters can be determined using the following equations.

For the accident rate, the accident rate in section j (R_j) and the critical rate (R_c) with 95 percent confidence are shown

in Equation 2 and Equation 3, respectively.

$$R_j = \frac{A_j}{m_j} \quad (2)$$

$$R_c = \hat{\lambda} + 1.645\sqrt{\hat{\lambda}/m_j} - 0.5/m_j \quad (3)$$

Where A_j = Number of accidents on section/intersection j, m_j, = Number of vehicle kilometers in millions on section j or number of vehicle in millions on intersection j during the same time period, $\hat{\lambda}$ = Average accident rate for all road sections/intersections.

For the accident frequency, the accident frequency in section j (A_j) and the critical value (A_c) with 95 percent confidence are shown in Equations 4 and 5, respectively.

$$A_j = \frac{A_j}{L_j} \quad (4)$$

$$A_c = F_{avg} + 1.645\sqrt{F_{avg}/L_j} - 0.5/L_j \quad (5)$$

Where A_j = Number of accidents on section j, L_j = Length of road section/ intersection. , F_{avg}= Average of accident frequency for all road sections/intersections.

For the accident severity, the severity value for section j (sj) can be calculated as shown in Equation 6.

$$sj = W_f (F_j) + W_s (I_j) + W_d (PDO_j) \quad (6)$$

Where F_j, I_j, PDO_j = Number of fatal accidents, serious injury accidents and property damage only accidents at section j, respectively, W_f, W_s, W_d = Calibration factors (weight factors).

The critical value (S_c) with 95 percent confidence can be calculated as shown in Equations 7.

$$S_c = S_{avg} + 1.645\sqrt{S_{avg}/L_j} - 0.5/L_j \quad (7)$$

Where S_{avg} = Average severity value for all sections/intersections, L_j= Length of road section/intersection.

4. Public Participation Approach

Determining whether a site has a "safety problem" is frequently based on the accident history for the road as mentioned in the previous section. However, implementation of such program requires relevant accident data, which are normally unavailable or limited in developing countries. Nevertheless, there are other inputs such as public input that proved to be useful in the identification processes (13, 14, 15). In Thailand, the success of utilizing public input in the black spot identification process was also revealed (16, 17).

Kowtanapanich et al. (16) proposes the framework of an Accident Public Participation Program (APPP) to assist the road user to report/inform the site with poor safety performance. The real world

applications of such a program are presented through a selected case study in Khon Kaen City. The findings indicate statistically significant agreements between the two datasets-the user inform locations and the black spot location identified by using historical accident data. This implies that residence can identify locations where accidents occurrences are unusually high and their input is potentially useful for the identification process. In addition, besides the indirect benefits to creating public awareness, the proposed methodology is potentially useful as a means for both speeding up and economizing the black spot locations identification process.

Fukuda et al. (17) introduce Hiyari-Hatto method to identify and collect data on existing and potential black spot locations. The Hiyari-Hatto, initiated in Japan, is a traffic psychological method to encourage road users to participate/involve in the traffic safety program in order to elicit information through their expression of potential accident experiences that almost occurred/caused them dead or injured (17). The empirical study was conducted in Soi Chokchai 4 and Soi Ladprao 39 in Bangkok. The findings from this study indicated that Hiyari-Hatto method is a significant alternative method for public participatory enhancement to develop black spot database nationwide.

5. GIS Applications

Since accident is spatially distributed in nature, use of Geographic Information System (GIS) and database software will provide the capability to store data, update data, retrieve data, compare data and spatially display the data (18, 19, 20, 21, 22). These modern computer technologies allow black spot map to be electronically generated from a well-designed accident database. Computer record systems can also produce rankings of high-accident locations based on either total accidents occurring or accident rates. In terms of economics, Hall et al. (18) proved that GIS implementation offered large benefits for accident analysis and program development.

Due to the reasonable aspect as previously mentioned, many researchers (19, 20, 21, 22, 23) employed this tool for their research studies.

In Thailand, the used of GIS for accident analysis is introduced by Ruengsorn et al. (23). This study initiated a GIS road accident database system in Khon Kaen Municipality. Through the developed systematic linkage between road data and injury data in the GIS environment, black spot locations in the study area are identified and any accident analysis based on Trauma Registry database can be performed spatially. Results and methodology from this study provide a resource base for future development of safety research and

applications in Khon Kaen as well as nationwide.

6. Conclusion

Road accidents are considered as one of the top three public health problems in Thailand (1). Despite the Government's best efforts in recent years, unfortunately, there are still over 12,000 deaths and more than one million injuries each year as the result of road accidents, with several hundred thousand people disabled (1).

To overcome the situation, one of the government's safety programs to help curb road accidents in the country is to implement the black spot improvement program. Lessons learned through the developed countries have made it evident that a black spot treatment program is an effective, reactive means for dealing with the occurrence of accidents. To implement such program, the first and most important step is to identify the site for safety improvement.

This article discusses two main approaches to identify black spot location currently practiced in Thailand. The first one is a classical approach which relies on the historical accident occurrence. Several methods such as accident number, accident rate, quality control approach, and severity index are addressed. The second approach is proposed as an alternative approach to identify black spot when accident data are limited or not available at the site. For this method, the public participation tactics is utilized to gather public input locations to identify the potential black spot locations.

Besides the identification method, the modern technologies to facilitate the black spot improvement program are also discussed in this article.

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